Exploring the odds of diabetes and physical activity as an effect modifier in the Kohala Research Project: A multi-ethnic secondary data analysis of a cross-sectional study

by

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Abstract:

Diabetes is a chronic disease that affects people globally. With the increasing odds of diabetes and it becoming the 7th leading cause of death, it is important to see what lifestyle choices that can be modified to live a healthier life. Objective: This project looks at the odds of developing diabetes in terms of physical activity amongst the following ethnic groups in Kohala, Hawaii: Caucasian, Filipino, Hawaiian or Part Hawaiian, and Japanese. Methods: This is a secondary data analysis of a cross-sectional study from the Kohala Research Project in which data was collected between 1997-2000. Men and non-pregnant women aged 18 years or older were eligible to participate in the study where blood samples were acquired and an intensive questionnaire was given. Results: It was found that physical activity is protective for Caucasians, Filipinos, and Hawaiian/Part Hawaiians, but it had an increased odds of developing diabetes for Japanese.

Chapter 1: Introduction

What is diabetes?

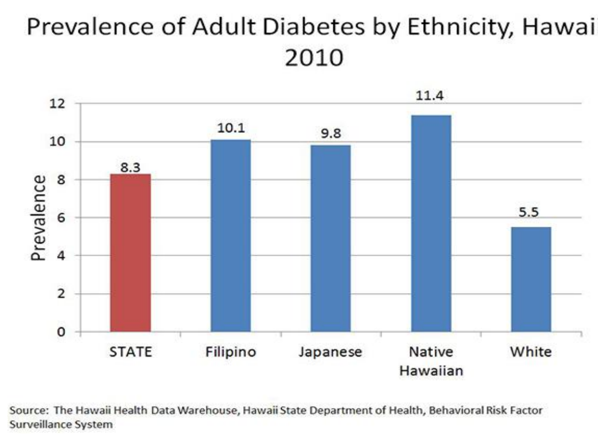
Diabetes is a chronic disease that impacts people globally. According to the World Health Organization [1], 347 million people worldwide are suffering from diabetes and is predicted to become the world's seventh leading cause of death by 2030 (2014). Diabetes occur when there is too much sugar in the bloodstream and there is an insufficient amount of insulin to carry the sugar into the cells. This build-up of excessive sugar in the blood (high blood sugar) can lead to many detrimental complications such as neuropathy, eye complications, stroke, and cardiovascular diseases [2]. In the United States (US), there are more than 29 million people who are diagnosed with diabetes, while 89 million people of the US population are prediabetic (Unfortunately, 25 percent of the US population does not know that they have diabetes and 33.33 percent does not know that they are prediabetic [3].

The 2014 Diabetes Report Card from the Centers of Disease Control and Prevention (CDC) [4] states that a large portion of the population does not know the importance of the disease. To them, it is a condition where one needs to limit their sugar intake but does not have sufficient knowledge to determine the reason behind it (2014). In an article, *Barriers to diabetes management: Patient and provider factors* [5], Nam et al. discussed why knowledge and diabetes care have inconsistent outcomes (2011). In their article, the authors discussed that their study participants know that "HbA1c (glycated hemoglobin) test result is associated with a more accurate assessment of diabetes control" [5]. However, this does not demonstrate their increased risk and motivation in ensuring that they improve their self-management for diabetes.

The disconnect between pursing the instructed diabetes self-management care and just knowing it lies in the patients really knowing the reason behind why they are doing certain things. For instance, Nam et al. [5] report that many participants do not know the purpose behind the self-management strategies and does not know the direct benefit (2011). Effective communication is essential in disease care because it puts patients at ease, it reduces their anxiety about the medications that they are taking, and it improves patients' compliance to recommended care [6].

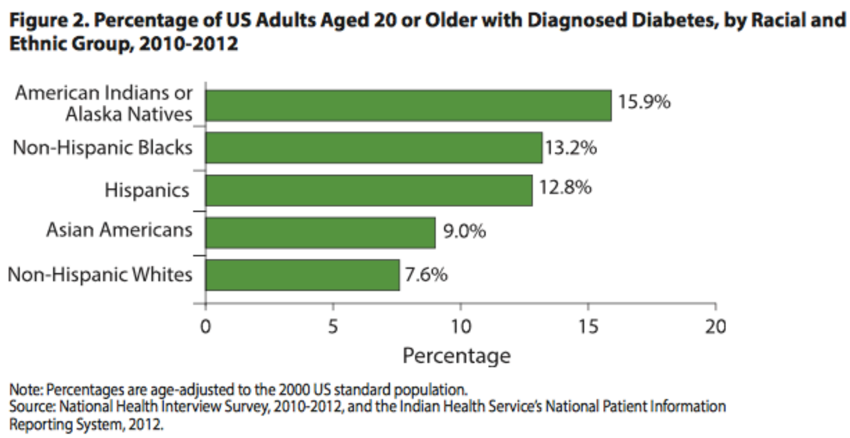
Diabetes in Hawaii:

Diabetes is an important issue in Hawaii. In 2009, the State of Hawaii, Department of Health (DOH) stated that diabetes is the fifth leading cause of death in the state where the prevalence has been increasing over the years. It is also most prevalent in the older population and in the Native Hawaiian ethnic group, followed by the Filipinos in Hawaii as seen in figure 1 [7].



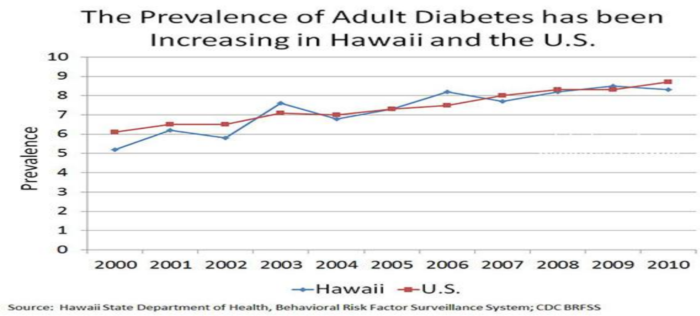
Source: The Hawaii Department of Health
Figure 1: illustrates the prevalence of adult diabetes by ethnicities in 2010 in Hawaii.

Howard Koh, assistant secretary for health at the US Department of Health and Human services, wrote about the burden of diabetes on the Native Hawaiian and Pacific Islander communities [8]. In his article, Koh wrote that there is an increased risk for Native Hawaiian and Pacific Islander communities in which they "are more than three times more likely to be diagnosed with diabetes, compared to non-Hispanic whites" [8]. This is important to highlight because there is a difference in distribution between ethnic groups in Hawaii and the US adults. Below, figure 2 illustrates the breakdown of diabetes by ethnic groups but they do not list down Native Hawaiians nor Pacific Islanders [9]. Furthermore, the ethnic group distribution in the United States is different in the ethnic group distribution of diabetes in Hawaii.



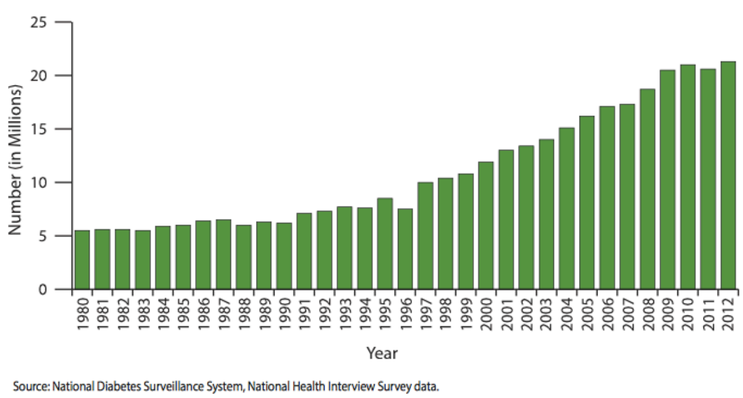
Source: Centers for Disease Control and Prevention
Figure 2: illustrates the percentage of adult diabetes by ethnicities in 2010 in the US.

According to the Hawaii State DOH, Behavioral Risk Factor Surveillance System (BRFSS), the prevalence in 2000 was 5.1 per 100 people. However in 2013, the prevalence increased up to 7.5 per 100 persons as seen in figure 3 [9]. To account for the age differences and the impact of age as a confounding factor, the prevalence (5.1 and 7.5 per 100 in 2000 and 2013 respectively) were age adjusted by BRFSS [10]. Due to the seriousness of this matter, the government is investing "about $770 million on diabetes-related medical costs," hoping to increase prevention and disease management [11]. The prevention and disease management effort seems to be working in Hawaii since the incidence report/new cases of diagnosed diabetes is below the nation's median. In 2013, Hawaii's incidence of diabetes was 5.2 per 1000 while the US's incidence median is 7.9 per 1000 [10].



Source: The Hawaii Department of Health
Figure 3: illustrates the trend of adult diabetes in Hawaii in comparison to the US.

Overall, the prevalence of diabetes has increased over the years. The 2014 CDC Diabetes Report Card shows that the prevalence of diabetes has dramatically increased from 1980 to 2012 as seen in figure 4. This quadrupled trend predicts that "1 out of every 3 adults in the United States could have diabetes by 2050" [4] although 1 out of every 2 children in Hawaii born after the year 2000 will develop diabetes in their lifetime [12].



Source: Centers for Disease Control and Prevention
Figure 4: illustrates the number of US adults aged 18 or older that are diagnosed with diabetes from 1980-2012

Diabetes can lead to mortality but some of the risk factors are manageable. Age, familial history, and ethnicity are demographic characteristics that cannot be changed while socioeconomic status (SES) is not an aspect of a person's life that is readily changeable. However, lack of physical activity and obesity are risk factors in which a person has control over. People who are obese are more likely to have poor control of their blood pressure, sugar intake and cholesterol levels [4]. Therefore, preventing obesity and engaging in recommended physical activity is essential in preventing and/or maintaining diabetes.

Goal of this paper:

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) states that "physical activity helps [a person's] blood glucose … stay in [his or her] target range" by helping the person's insulin hormone to use the blood glucose for energy, rather than having it build-up from the bloodstream [13]. Because ethnicity is a risk factor for diabetes but physical activity can have a protective effect, it is important to see how gene-environment interaction impacts an individual. Therefore, it is hypothesized that the odds of developing diabetes will vary between ethnic groups in the Kohala Research Project. However, the odds of developing diabetes can be modified if participants engage actively in physical activity.

Chapter 2: Literature Review

In 2008, different departments came together to look at dietary patterns in Caucasian, Filipino, Hawaiian and Japanese to see the prevalence of Type 2 diabetes. Their study supports that the groups who ate predominantly "fruits, vegetables, and bean products, positively correlated with lower body mass index (BMI) and [waist-to-hip ratio] values" [14]. This finding indicates that environmental and behavioral factors play an important part. People in higher SES are more likely to eat fruits, vegetables, and bean products because they are more educated, and they have higher income; thus, being able to afford healthy foods more readily than those with lower SES. This project looks at an important information, one being the involvement of ethnicity and genetics [14]. Research shows that genetics play a significant role because certain ethnicities are more predisposed to diabetes due to their insulin resistance. As a result, this group of researchers believe that there should be more attention to promoting health for different ethnicities in Hawaii. Hawaii is known to be a melting pot due to the wide variation of ethnicities; thus, with genetics playing an important role, the need to consider the different methods of addressing health promotion to different groups of people is essential [14].

To suggest whether physical activity recommendations should also be ethnicity-specific, a group of researchers compare South Asian and European men. In the study by Celis-Morales et al., they have preliminary data that suggests that the "dose-response relationship between physical activity and risk factors for metabolic disease differs substantially between populations of different ethnicities" [15]. One reason for this preliminary finding is that South Asian groups are at a higher risk for diabetes and cardiovascular diseases because they have a "lower levels of cardiorespiratory fitness and a reduced ability to oxidize fat during exercise" [15]. There were 75 South Asians and 83 European men that were recruited in this project in which physical characteristics such as height, body mass, and waist circumference were measured. Furthermore, they also wore accelerometers to record data for analysis. It was found that South Asian men would need to engage in more moderate-intensity physical activity than European men to achieve the same protective health benefit [15].

In a different study that looked at physical activity, sedentary behaviors and the incidence of type 2 diabetes, Joseph et al. presented Hazard Ratios for Non-Hispanic White, Chinese-American, African-American, and Hispanic-American [16]. There were 5,829 men and women from the Multi-Ethnic Study of Atherosclerosis that participated and were drawn fasting blood samples to measure glucose markers. In their analysis, chi-square was used to compare categorical variables and Cox proportional hazards to estimate hazards ratios while adjusting for sex, education, occupation status, systolic blood pressure, and smoking status [16]. In their study model, walking was categorized by the participants' pace, physical activity was broken down by quartiles, and leisure sedentary behaviors such as reading and television watching were explored. In the final analysis, it was found that vigorous physical activity has a reduced effect for diabetes for Non-Hispanic White. The other three ethnic groups also had small protective effect but they were not statistically significant. This could be because of the diet factor that was not included and adjusted for. Another limitation for the project could also rise from the inconsistency of the physical activity data that were reported. An inaccuracy of the data could lead to a non-differential misclassification and results could be biased towards the null [16].

Besides looking at ethnicity and physical activity as risk factors for diabetes, a group of researchers looked at waist circumference as a risk factor in comparison to waist-hip ratio and waist-height ratio amongst women. In this case-control study that was conducted in Lithuania, there were 168 cases (1:2 ratio of cases to controls) that were included in which the women were asked to fast for “12 hours and to avoid smoking and heavy physical activity for at least 2 hours before examination” [17]. During the participants’ visits, they were asked about their familial history, education, occupation, nutrition, alcohol consumption, smoking status, and stress level using a questionnaire. Height and weight were measured twice and weight and hip circumferences were measured in centimeters for accuracy.

During analysis, the researchers created categories and cut-off points for weight circumferences and justified that waist-hip ratio is a better predictor of diabetes than BMI using the Hoorn Study. In their study of the different anthropometric indexes as a risk factor for diabetes, Radzeviciene and Ostrauskas [17] found a 500% increase odds of developing diabetes for those who had greater than 88cm waist circumference than those that had less than 80cm. When comparing Waist-hip ratio, they found a 46% increase odds for those that had a waist-hip ratio of greater to 0.85 compare to those that had a ratio of 0.85 or less. Finally, they found a 244% odds increase of diabetes when comparing a greater or equal to 0.5 waist-height ratio to someone with less than 0.5 [17]. In addition to Radzeviciene and Ostrauskas, there was a meta-analysis study that was done, which supports the use of waist-circumference and waist-hip ratio as suggestive factors of diabetes [18]. In their conclusion, Vazquez et al.’s [18] research contributes to the growing evidence of the association between BMI, waist-circumference and waist-hip ratio and the prevalence of diabetes [18].

Other variables that are explored in the field of diabetes research are demographic information and familial history. In a research done by Annis et al [19], they looked at gender, age, ethnicity, income, education, BMI, and family history (2005) using the National Health and Nutrition Examination Survey (NHANES) data. For their analysis, a multivariate analysis was performed using four regression models in which odds ratios were obtained. As a result, they found that familial history was a significant predictor of diabetes where a person is at a 4 times greater odds of developing diabetes if their parents or siblings are diabetic [19].

Chapter 3: Methods

Data Collection:

The Kohala Research Project was a cross-sectional study that was conducted between 1997-2000 where all men and non-pregnant women aged 18 years or older were eligible to participate. The participants were asked to fast for 10-14 hours in which fasting glucose was acquired. Furthermore, during their check-up, blood pressure, weight, height and waist circumference were obtained, followed by a questionnaire that asked about their physical activity, diet, medical and familial history, and demographic information.

Analytic Methods:

Using the data from the Kohala Research Project, the student researcher uses the participants' diabetes status as an outcome variable where physical activity and ethnicity are the main explanatory variables. Physical activity was used as a categorical variable where the participants were identified as either active or not active using their metabolic equivalence calculation. Based on the literatures, variables such as smoking status (categorical variable), income level (categorical variable), and age (continuous variable) were considered as a potential confounder, variables that are predictive of both the outcome variable and the explanatory variable; BMI (continuous variable), weight categories (categorical variable), and waist circumference (continuous variable) were considered to be potential mediators, variables that were potentially part of the causal pathway. With this information, SAS University and R were the two statistical soft-wares that were used for data analysis due to its consistent used in Public Health.

The first step was data exploration where the students looked at frequencies of participants' smoking status, household income, gender, ethnic and diabetes distribution. After getting familiar with the dataset, the student researcher looked at data stratification by physical activity and was broken down by ethnicity to see how participants from different ethnic groups varied from each other.

From then, four logistic regression models, stratified by ethnicity were created to see the effects of the different variables. The models were stratified by the four different ethnic groups to see how the odds of developing diabetes varied for the different variables amongst the different ethnic groups; hence, allowing the student researcher to see if there are ethnic differences. The first model is the unadjusted model where diabetes status was compared to physical activity – whether the person is physically active or not. Then, the second model was built by adjusting for age and gender because there could be gender difference while age is an important factor because an increased in age is associated with an increased risk of developing diabetes while the older population are more likely to exercise less. For the third model, all the other variables such as household income, smoking status, BMI and waist circumference were added to see the effects as seen in the literatures which identified these as potential confounders. Lastly, the fourth model was modified to only include physical activity, age, BMI, gender and waist-circumference.

Chapter 4: Results

Table 1: Frequency of participants for each of the following explanatory variables: gender, smoking status, ethnicity, household income, weight category, diabetes status and physical activity status (n=1,186) from the Kohala Research Project. The missing variables were excluded in the logistic models.

Variables		Frequency (n)	Percentage (%)
Gender	Male	545	45.99%
	Female	640	54.01%
	Missing	1	~ 0%
Smoking Status:	Never	528	44.52%
	Past	380	32.04%
	Current	201	16.95%
	Missing	77	6.49%
Ethnicity:	Caucasian	293	24.70%
	Filipino	186	15.68%
	Hawaiian/Part Hawaiian	517	43.59%
	Japanese	190	16.02%
Household Income	<$15,000	199	16.78%
	$15,000-$24,999	228	19.22%
	$25,000-$34,999	237	19.98%
	$35,000-$49,000	216	18.21%
	$50,000-$74,999	206	17.36%
	> $74,999	80	6.75%
	Missing	20	1.69%
Weight Category:	Obese	343	28.92%
	Overweight	402	33.90%
	Normal	412	34.47%
	Underweight	17	1.43%
	Missing	12	1.01%
Diabetes Status:	No	998	84.15%
	Yes	188	15.85%
BMI:	*(Mean, Standard Deviation)*	27.97	6.96
Diabetes Status:	No	998	84.15%
	Yes	188	15.85%
Physically Active Status:	No	850	71.67%
	Yes	273	23.02%

	Missing	63	5.31%
Age:	*(Mean, Standard Deviation)*	49.17	15.76
Waist Circumference (cm)	*(Mean, Standard Deviation)*	92.359	15.066

Recall that there were four different ethnicities that were included in this project: Caucasian, Filipino, Hawaiian/Part Hawaiian and Japanese. Using figure 1, it can be seen that there is a relatively close distribution of gender, household income and weight category. However, there was a large amount of participants' who are not diabetic while many of them do not exercise actively (about 71.67%) as seen in table 1.

Table 2: Bivariate analysis of table 1 variables stratified by diabetes status.

Variables		**Diabetes Status**			
		Yes (n)	**Percentage**	**No (n)**	**Percentage**
Gender	Male	88	16.15%	457	83.85%
	Female	99	15.47%	541	84.53%
Smoking Status:	Never	80	15.15%	448	84.85%
	Past	67	17.63%	313	82.37%
	Current	24	11.94%	177	88.06%
Ethnicity:	Caucasian	13	4.44%	280	95.56%
	Filipino	36	19.35%	150	80.65%
	Hawaiian/Part Hawaiian	99	19.15%	418	80.85%
	Japanese	40	21.05%	150	78.95%
Household Income	<$15,000	31	15.58%	168	84.42%
	$15,000-$24,999	42	18.42%	186	81.58%
	$25,000-$34,999	41	17.30%	196	82.70%
	$35,000-$49,000	30	13.89%	186	86.11%
	$50,000-$74,999	28	13.59%	178	86.41%
	> $74,999	9	11.25%	71	88.75%
Weight Category:	Obese	96	27.99%	247	72.01%
	Overweight	56	13.93%	346	86.07%
	Normal	32	7.77%	380	92.23%
	Underweight	0	0%	17	100%

Physically Active	No	135	15.88%	715	84.12%
Status	Yes	36	13.19%	237	86.81%

Table 3: The breakdown of diabetes status and physical activity status by ethnicity

Ethnicity	**Physically Active**		**Not Physically Active**	
	Diabetes Status:			
	No	**Yes**	**No**	**Yes**
Caucasian	83	3	189	10
Filipino	22	4	122	30
Hawaiian/Part Hawaiian	104	17	287	69
Japanese	29	12	117	26

Furthermore, looking at participants who were physically active and their diabetes status, there were only 43 participants who are both physically active and are diabetic; 165 participants are diabetic and are not physically active while 297 participants are physically active and are not diabetic. Majority of the participants were non-diabetic who are also not physically active (857 participants) as seen in Table 2. To see the population distribution of those that are diabetic and non-diabetic with their respective physical activity status, table 3 illustrates the spread by ethnicities.

In table 4, the odds ratios for diabetes and physical activity are seen by ethnic groups in which 4 models were used: unadjusted and varying adjustments for models 2-4. The models generally illustrated that physical activity has a protective effect for diabetes for the different ethnic groups except for the Japanese. In table 5, other variables were used to see their relationship with diabetes. Using model 4, it was found that there are a 4-8% increase odds of developing diabetes for the four different ethnic groups. Similarly, there could be gender differences between male and female in developing diabetes yet the ethnic group also plays a role. For example, being a male is protective in developing diabetes although the result was non-statistical significant. Furthermore, table 5 illustrates that there is an increased odds of developing diabetes for those who are at a higher BMI and waist circumference.

Table 4: The odds ratio for diabetes mellitus and physical activity by ethnic groups using inactive as a reference.

Models	Ethnic Groups			
	Caucasian	**Filipino**	**Hawaiian/Part Hawaiian**	**Japanese**
Model 1:	0.691 (0.185, 2.578)	0.740 (0.237, 2.307)	0.680 (0.382, 1.210)	1.862 (0.840, 4.126)
Model 2:	0.818 (0.213, 3.146)	0.526 (0.158, 1.753)	0.754 (0.404, 1.407)	1.692 (0.729, 3.926)
Model 3:	0.995 (0.237, 4.173)	0.409 (0.099, 1.690)	0.586 (0.289, 1.186)	1.625 (0.638, 4.140)
Model 4:	1.001 (0.248, 4.037)	0.591 (0.159, 2.195)	0.561 (0.278, 1.132)	1.506 (0.598, 3.797)

Legend: Model 1: unadjusted model
Model 2: age and gender adjusted
Model 3: age, gender, BMI, WHR, smoke, household income adjusted
Model 4: age, gender, BMI, and WHR adjusted

Table 5: The odds ratio for diabetes mellitus and other covariates such as age, ethnicity, gender, BMI, and Waist circumference.

Age	1.063 (1.048, 1.077)
Filipino vs. Caucasian	3.806 (1.883, 7.693)
Hawaiian vs. Caucasian	3.793 (1.997, 7.206)
Japanese vs. Caucasian	3.168 (1.572, 6.386)
Gender	0.957 (0.659, 1.390)
Waist circumference	1.016 (0.999, 1.034)
BMI	1.069 (1.027, 1.112)

Chapter 5: Discussion

From this research project, it was found that physical activity has a protective effect for Caucasian, Filipino, and Hawaiian/Part Hawaiian yet it has an increased odds for Japanese, though the results were not statistical significance. One reason why the Japanese ethnic group could have had an increased odds of developing diabetes is because the mean age for this group is older. Recall that age is a confounding variable because older populations are at an increased risk for developing diabetes while they tend to engage in less physical activity. Another reason why the Japanese are at an increased odds is because majority of them could have been previously diagnosed with diabetes; hence, making different lifestyle choices such as engaging in physical activity to reduce the effects of diabetes.

In table 4, there were different logistic models with varying variables that were included in the analysis with the exclusion of the missing variables. After the third model which included age, gender, smoking status, household income, BMI and waist circumference, both household income and smoking status were dropped from the model to produce model 4. The reason for dropping smoking status and household income was because it showed insignificance in the overall model and were supported by literatures that illustrated the inconsistency of smoking status as a predictor of diabetes. Initially, it was thought that this would serve as a potential confounder but the results of the odds ratios had limited effect on the results.

In this secondary data analysis, majority of the participants were non-diabetic in which 857 of them was not physically active while 297 of them were physically active. This illustrates that of those that were non-diabetic, there was about 1:3 ratios of non-physically active in comparison to those who were active. On the contrary, there were 165 participants who are diabetic that are not physically active while 43 of those with diabetes are active (table 2).

Furthermore, referring back to table 1, it can be seen that there was a 5:1 ratio of non-diabetic to those that are diabetic. This posed some limitations because when the 188 participants who are diabetic were stratified into their respective ethnic groups, the data lost statistical power. Another limitation in this research project was the stratification. Refer to table 1 to see the breakdown of ethnicities. Recall that majority of the participants were Hawaiian/Part Hawaiian, 293 participants were Caucasian, while both Filipinos and Japanese were under 200 participants each. Statistical power is dependent on the effect size and the sample size. Because there were only 188 participants that were diabetic and the numbers of the sample sizes for each respective, the statistical power for this stratification was decreased; thus, could be the reason why the results were non-significant. Additionally, when each of the ethnic groups were further stratified by their physical activity and diabetes status as seen in table 3, some ethnic groups such as Caucasian have very small sample size that were physically active and diabetic (n=3) and also a very small sample size that were diabetic and was not physically active (n=10).

Another limitation of this study was not including nutrition information. Nutrition would have been a good concept to include in the study because if a person is not exercising regularly but is avoiding the consumption of food with high sugar, then they could also be protected against diabetes. Diet has shown to be very important in maintaining good health.

Lastly, another limitation of this research project is that questionnaires were used to acquire data about the participants' physical activity information. This could lead to social desirability bias because participants' can over estimate their exercise activity because they know that being physically active is a healthy choice.

There were several strengths in this research project. First, the overall sample size was big, where it was over 1000 participants who came in a screening in Kohala, Hawaii. Heights, weights, waist circumference, blood sample, and blood pressure were obtained; thus, limiting reporting bias if participants had reported their heights and weights. The obtained height, weight, and waist circumference were used to calculate the participants' BMI and WHR. The blood sample collection was a strength because it allowed the participants who did not know whether they were diabetic or not to find out if they were based on their fasting glucose. By drawing the patients' blood samples, the researchers were able to confirm whether the participants were true diabetic and not. Furthermore, an extensive questionnaire was used that asked about the participants' demographics, medication information, physical activity, and nutrition. Although the questionnaire itself was extensive, participants' metabolic equivalents were measured and determined if they were active or not. However, problems may rise with this because there was no breakdown for their activities. If the physical activity was itemized, it would allow the researchers to determine whether the rigor of the activity itself.

For future direction, if this study was to be used as a foundation to see the prevalence and odds of diabetes in Hawaii, it is recommended that a larger size for each ethnic groups would be acquired as well as the prevalence of diabetes in each ethnicity. However, if this project was to be revisited, a different direction could be analyzing results with ethnicity as a whole to increase statistical power and see the effects that ethnicity have on the model. Lastly, it would be good to go back to the questionnaire and separate out the physical activity into the respective exercise groups. For example, instead of calculating the overall metabolic equivalence (MET), the different METs can be calculated to see the rigor of the activity itself and the location. This would tie back to the Biophilia hypothesis that people are naturally drawn to nature and that they seek connections with nature and other form of life. Therefore, if a researcher could determine the location of the physical activity, whether it is indoor or outdoor, exercise durations and rigor could be better estimated to see the effects of physical activity.

Although this project had non-statistical significant odds ratios, it was statistically significant that age has an increased odds of developing diabetes while there could be gender differences depending on the ethnic groups. Furthermore, an increased in BMI also illustrated an increase of odds of developing diabetes. This could mean that maintaining a healthy BMI serves a role as a protective effect for diabetes. In terms of gender, it is important to know this factor to make recommendations for women and men in different ethnic groups to take extra preventive measure knowing that their gender could put them at greater odds of developing diabetes or if it can be a preventive effect.

When the model looked at ethnicity as a whole (non-stratified), it was found that Filipino, Hawaiian, and Japanese had an increased odds of developing diabetes compared to Caucasian as seen in figure 5. This is supported by the State of Hawaii DOH and seeing the effects indicate that ethnic is an important factor to explore.

Chapter 6: Conclusion

In conclusion, physical activity is essential in maintaining a healthier lifestyle and that it should be encouraged and be adapted in people's life to prevent chronic diseases such as diabetes and obesity. In the future, more research should be done with greater sample size for each ethnic groups or analyzing the results as a whole without stratifying to see the effect of physical activity on diabetes. Another direction would be to look at the different exercise that the participants identified and create different metabolic equivalent for each exercise to see the association between the different types of physical activity, exercise location and diabetes.

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